6,251,488, issued June 26, 2001). Both the parent application and the present divisional application correspond to International Application No. PCT/US00/09287, filed April 7, 2000.

A Written Opinion for the PCT application was mailed on April 11, 2001 addressing Claims 1 - 40. The prior art references applied in the Written Opinion are identified as follows: U.S. Patent Nos. 4,947,463 (Matsuda et al); 5,607,730 (Ranalli); 5,449,536 (Funkhouser et al); 5,733,609 (Wang et al); and 5,612,099 (Thaler). Each of these references has been cited of record in connection with the prosecution of U.S. parent application S.N. 09/305,985.

A response to the Written Opinion was filed in the Patent & Trademark Office on June 8, 2001. The response amended Claims 1, 29, 31 and 32; added new Claims 41 - 71; and cancelled Claims 30, 33, 36, 39 and 40, without prejudice. The response to the Written Opinion also advanced arguments distinguishing the revised and newly added claims over the cited prior art references. Examiner Kolb, who is the Authorized Officer in charge of the PCT application, has advised the undersigned that the revised and added claims presented in the response to the Written Opinion are deemed to be patentable (i.e., have novelty,

industrial application, and exhibit an inventive step) over the prior art references cited in the Written Opinion.

This Preliminary Amendment revises the claims pending in the present divisional application to correspond identically to the claims presented in response to the Written Opinion issued in connection with the corresponding PCT application. Applicant therefore submits that all claims pending in the present divisional application are in proper form for allowance.

As discussed in the Formal Response To First Written Opinion filed in the corresponding PCT application, Claim 1 has been revised and PCT Claims 67 - 68 (designated as Claims 62 - 63 in this Preliminary Amendment) have been added to more clearly define the nature of the claimed invention. Claims 69 - 71 of the PCT application (corresponding to Claims 64 - 66 of this Preliminary Amendment) are directed to apparatus for performing the methods defined by independent Claim 1 and the claims depending therefrom. Claim 1, as revised, defines patentable subject matter over the prior art for the reasons to be discussed as follows.

Turning first to the Matsuda et al patent, this citation discloses a laser beam 1 reflected by a lens 2a such that the reflected laser beam 1′ is not substantially parallel to the

direction of flow of material indicated by reference numerals 5 and 6. Independent Claim 1, as revised herein, recites a method for material deposition in which the direction of transmission of the laser beam is substantially parallel to the direction of flow of the carrier gas, and the flow of the carrier gas and laser beam are substantially perpendicular to the surface of the substrate on which the material is deposited.

The Ranalli patent discloses a device in which a laser beam is initiallly reflected by a mirror 20, and thereafter focused by a lens 56 on a substrate 50. Material to be deposited on the substrate is introduced by a carrier gas at an angle other than normal relative to the surface of the substrate on which the material is to be deposited. (See Figure 2, and Column 7, lines 6 - 8 and 20 - 22 of the Ranalli specification). Independent Claim 1, as revised herein, recites a method in which the direction of transmission of a laser beam is substantially parallel to the direction of flow of a carrier gas for the material to be deposited, and that the laser beam and carrier gas are oriented substantially perpendicular to the surface on which the material is to be deposited.

The Funkhouser et al patent discloses a device in which material is introduced at an acute, not perpendicular, angle relative to the surface of the substrate on which the material is

to be deposited. See, injectors 33, 34, 44 and 54 relative to substrate surfaces 35, 45 and 55, respectively, as illustrated by Figures 3 - 5 of the Funkhouser et al drawings. Figures 3 and 4 also disclose a laser beam striking a substrate surface at an angle other than perpendicular. Independent Claim 1, as revised herein, recites a method in which the carrier gas containing material to be deposited flows substantially parallel to the direction of transmission of the laser beam, and that the direction of flow of the carrier gas and the direction of transmission of the laser beam are substantially perpendicular to the substrate surface on which the material is to be deposited.

The Wang patent discloses a device in which a laser beam 1 is reflected a several different times by reflectors 3, 4 and 5 such that the laser beam is being transmitted at an angle, and not substantially parallel, to the carrier gas 7 at the location at which the laser beam is applied to the carrier gas. Moreover, the laser beam is being transmitted in a direction opposite to the flow of the carrier gas 7 at the point at which the laser beam is first introduced to the material in the carrier gas to be deposited on the substrate 9. Independent Claim 1, as revised herein, recites a method in which the flow of the carrier gas containing the material to be deposited on a substrate surface is substantially parallel to the direction of transmission of the laser beam applied to the material.

The Thaler patent discloses a laser 20 transmitted in a direction substantially perpendicular to a substrate surface (See Figure 1 of the drawing). However, a carrier gas 14 flows in a direction which is substantially perpendicular, and not substantially parallel, to the direction of transmission of the laser 20. The purpose of the carrier gas as disclosed in the Thaler patent is not to cause the particles to flow towards the substrate. On the contrary, the carrier gas is provided to suspend the particles above the substrate surface (See Column 5, lines 29 - 34 of the Thaler specification). Deposition of the particles on the substrate does not result from the flow of the carrier gas, but is accomplished by other methods. (See Column 8, lines 19 - 33 of the Thaler specification). Independent Claim 1, as revised herein, recites that the flow of the carrier gas is substantially parallel to the direction of transmission of the laser beam, and that the laser beam and carrier gas are oriented substantially perpendicular to the surface of the substrate on which material is to be deposited.

* * *

Independent Claim 1, as revised herein, defines patentable subject matter over each of the five (5) references discussed above. The remaining claims which depend directly or indirectly from independent Claim 1, are allowable over the five references

discussed above for at least for the same reasons discussed herein with respect to independent Claim 1. Similarly, the apparatus claims for performing the methods of independent Claim 1 and the claims depending therefrom, define patentable subject matter over the five prior art references discussed above for the same reasons discussed with respect to independent Claim 1.

Independent Claims 29 and 31 have been presented to recite methods by which at least one or more feedstocks are passed through an intersection region of a plurality of laser beams. Claims directed to this aspect of the invention have been allowed in parent Application Serial No. 09/305,985. As discussed during the prosecution of the parent United States application, the prior art of record does not teach or suggest methods for direct material deposition including the step of passing a feedstock material through a laser beam intersection region. For example, the cited Matsuda et al patent does not disclose or suggest employing a plurality of laser beams in a direct material deposition method, and therefore does not disclose or suggest an intersection region of two or more laser beams as disclosed and claimed by Applicant.

Similarly, independent Claim 30 has been presented to claim a method in which a material is transported through a hollow

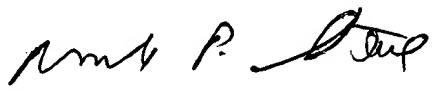
member. Claims directed to this aspect of the invention have been allowed in parent Application Serial No. 09/305,985.

As noted above, independent Claim 64 is directed to an apparatus for performing the methods defined by independent Claim 1. Independent Claim 56 is directed to an apparatus for performing the methods defined by independent Claim 30.

* * *

Applicant respectfully submits that all claims pending herein define patentable subject matter over each of the five (5) references discussed above which were cited in the Written Opinion issued in connection with the corresponding PCT international application.

Respectfully submitted,



Mark P. Stone
Reg. No. 27,954
Attorney for Applicant
Tel. (203) 329-3355

Revised Claim 1

Claim 1. (amended) A method for direct material deposition on a predetermined surface [substrate], the steps of said method comprising:

[(a) passing one or more feedstocks through a laser beam under conditions sufficient to convert substantially all of said feedstock(s) into a depositable form, and (b) depositing said depositable feedstock(s) on said substrate,

wherein said laser beam is generated by at least one laser, each operating at a power of up to about 1kW]

causing at least one feedstock to flow in a direction towards said predetermined surface;

applying a beam of energy to said material, said beam of energy being transmitted in a direction which is substantially parallel to the direction of flow of said feedstock; and

depositing said feedstock on at least a portion of said predetermined surface, said predetermined surface being oriented substantially perpendicular to the direction of flow of said feedstock and the direction of transmission of said energy beam.

Replacement Claim 1

Claim 1. (amended) A method for direct material deposition on a predetermined surface, the steps of said method comprising:

causing at least one feedstock to flow in a direction towards said predetermined surface;

applying a beam of energy to said material, said beam of energy being transmitted in a direction which is substantially parallel to the direction of flow of said feedstock; and

depositing said feedstock on at least a portion of said predetermined surface, said predetermined surface being oriented substantially perpendicular to the direction of flow of said feedstock and the direction of transmission of said energy beam.

New Claims 25 - 66

Claim 25. A method according to Claim 1, wherein multiple feedstock materials are selected and deposited under control of information provided in an electronic format.

Claim 26. A method according to Claim 1, wherein said feedstock material is deposited in a layerwise manner to create one or more components.

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Claim 27. A method according to Claim 26, wherein said feedstock material comprises two or more different materials.

Claim 28. A method according to Claim 1, wherein said laser beam(s) is/are focused approximately parallel to said deposition substrate.

Claim 29. A method for direct material deposition on a substrate, said method comprising the steps of:

passing at least a first material through an intersection region of a plurality of laser beams under conditions sufficient to convert substantially all of said first material into a depositable form, and

depositing said depositable first material on said substrate.

Claim 30. A method for direct material deposition, the steps of said method comprising:

applying energy to at least a first material proximate to an inlet end of at least one hollow member;

transporting said first material through said at least one hollow member to an outlet end of said at least one hollow member for guiding said first material towards a predetermined surface;

discharging said first material from said outlet end of said at least one hollow member; and

depositing said first material on at least a portion of said predetermined surface after said first material is discharged from said outlet end of said at least one hollow member.

Claim 31. A method for direct material deposition on a substrate, said method comprising the steps of:

passing at least a first material through an intersection region of a plurality of laser beams under conditions sufficient to convert substantially all of said first material into a depositable form,

focusing said depositable first material by employing guided laser deposition means, and

depositing said depositable first material on said substrate.

Claim 32. An article of manufacture produced by the method of Claim 1.

Claim 33. An article of manufacture produced by the method of Claim 29.

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Claim 34. An article of manufacture produced by the method of Claim 30.

Claim 35. An article of manufacture produced by the method of Claim 31.

Claim 36. The method as claimed in Claim 30 wherein said step of applying energy includes the step of applying at least one laser beam to said first material.

Claim 37. The method as claimed in Claim 30 wherein the step of depositing said first material on a predetermined surface includes the step of depositing said first material on a surface of a substrate.

Claim 38. The method as claimed in Claim 30 wherein said step of applying energy includes the step of applying energy to first and second materials for depositing said first and second materials on said predetermined surface.

Claim 39. The method as claimed in Claim 38 wherein the step of depositing said first and second materials includes the step of depositing said first and second materials in sequential layers on at least a portion of said predetermined surface.

Claim 40. The method as claimed in Claim 30 wherein the step of guiding said first material through said at least one hollow member includes the step of guiding at least said first material through a plurality of hollow members.

Claim 41. The method as claimed in Claim 30 further including the step of applying energy to said first material after it has been deposited on said predetermined surface.

Claim 42. The method as claimed in Claim 41 wherein said step of applying energy to said first material deposited on said predetermined surface includes the step of applying a laser beam to said first material deposited on said predetermined surface.

Claim 43. The method as claimed in Claim 36 wherein the step of applying a laser beam to said first material includes the step of applying a laser having a power of at least 1mW.

Claim 44. The method as claimed in Claim 43 wherein the step of applying a laser beam to said first material includes the step of applying a laser having a power of between 1mW - 1kW.

Claim 45. The method as claimed in Claim 30 wherein said hollow member is disposed between said first material and said predetermined surface for guiding said first material towards said predetermined surface for depositing said first material on said predetermined surface.

Claim 46. The method as claimed in Claim 30 wherein said first material is substantially reflective to reduce absorption of energy by said first material.

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Claim 47. The method according to Claim 30 wherein said depositing is carried out under conditions such that substantially no interfacial damage occurs to either said predetermined surface or said deposited material.

Claim 48. The method according to Claim 30 wherein said material is in finely divided particulate form when said energy is applied thereto.

Claim 49. The method according to Claim 48 wherein said energy applied to said finely divided particulate material is controlled by varying at least one of the time of flight of said finely divided particulate material through said energy zone, the

particle size of said finely divided particulate material, the angle of trajectory of said finely divided particulate material, the wavelength of said applied energy, or the quantity of energy of said applied energy.

Claim 50. The method according to Claim 49 wherein a trajectory path of said finely divided paticulate material is selected such that the energy reflected by some of the particles of material is incident onto other particles of said material within said path.

Claim 51. The method according to Claim 49, wherein said particles are less than about 40 microns in diameter.

Claim 52. The method according to Claim 48, wherein said finely divided material is comprised of charged particles.

Claim 53. The method according to Claim 52 wherein said material deposition is controllably aimed by passing said charged material through one or more electro-static and/or magnetic fields.

Claim 54. The method according to Claim 30, wherein said material comprises a dielectric material.

Claim 55. The method according to Claim 30, wherein said material is a resistive material, a conductive material, a semi-conductive material, or a magnetic material.

Claim 56. An apparatus for direct material deposition, said apparatus comprising:

at least one hollow member having an inlet end and an outlet end, said outlet end of said hollow member being oriented in a direction towards a predetermined surface;

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means for introducing a first material at said inlet end of said hollow member; and

means for applying energy to said material introduced at said inlet end of said hollow member for guiding said material through said hollow member and depositing said material on at least a portion of said predetermined surface.

Claim 57. The apparatus as claimed in Claim 56 wherein said means for applying energy includes a source of laser energy.

Claim 58. The apparatus as claimed in Claim 56 wherein said predetermined surface is a substrate.

Claim 59. The apparatus as claimed in Claim 56 further including means for applying energy to said material after it has been deposited on said predetermined surface.

Claim 60. The apparatus as claimed in Claim 56 further including a plurality of said hollow members.

Claim 61. The apparatus as claimed in Claim 56 further including means for introducing a plurality of materials at said inlet and of said hollow member.

a2 Claim 62. The method as claimed in Claim 1 wherein said predetermined surface is a substrate.

Claim 63. The method as claimed in Claim 1 wherein said energy beam is a laser.

Claim 64. An apparatus for direct material deposition on at least a portion of a predetermined surface, said apparatus comprising:

means for causing the flow of at least one material in a direction towards said predetermined surface and substantially perpendicular relative to said predetermined surface; and

means for transmitting a beam of energy applied to said flowing material, said beam of energy being transmitted in a

direction substantially parallel to the direction of said flow of said material and substantially perpendicular to said predetermined surface.

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Claim 65. The apparatus as claimed in Claim 64 wherein said predetermined surface is a substrate.

Claim 66. The apparatus as claimed in Claim 64 wherein said energy beam is a laser.